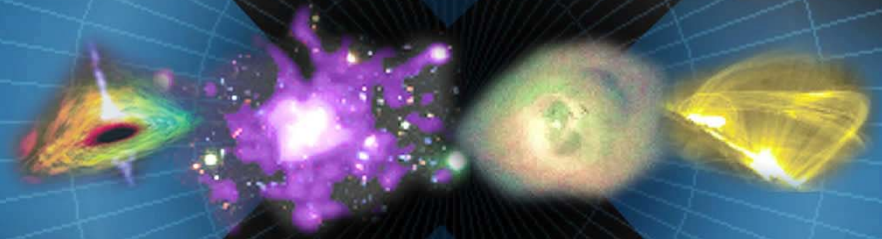


BEYOND EINSTEIN: From the Big Bang to Black Holes

Constellation

The Constellation X-Ray Mission



►► Reference Package for Con-X Science Enhancement Package RFI

October 12, 2006

Outline

- **Constellation-X Mission**
- **Single Atlas V Mission Concept**
 - Configuration and Layout
 - Basic Payload Performance Capabilities
- **Science Enhancement Package (SEP)**
 - Key Science areas for SEP
 - Design options
- **Summary**
- **Appendix A: Con-X Reference Mission Configuration**
- **Appendix B: Configuration and performance information for 3 SXT Atlas V alternative Con-X configuration**

Introduction

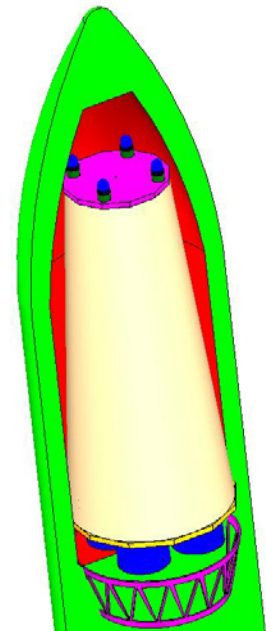
- **Constellation-X (Con-X), a flagship mission of the Beyond Einstein program, will explore the universe using large area, X-ray spectroscopy**
- **The current Con-X Reference Mission concept consists of a single satellite launched on a Delta IV H; concepts that utilize multiple satellites on multiple launch vehicles have also been studied in the past**
- **A streamlined mission approach is under study which will enable the mission to be launched in a single Atlas V launch vehicle and reduce overall mission costs**
- **The Atlas V mission payload consists of a basic mirror/instrument complement (4 Spectroscopy X-ray Telescopes) and a Science Enhancement Package (SEP)**
- **The goal of the SEP is to provide increased performance at the lowest and highest energies of the Con-X band pass, within mass and cost constraints**
- **This package provides reference material on the Con-X Atlas V configuration, for use in defining SEP concepts**

Constellation-X is a Great Observatory

- Constellation-X will mark the start of a new era when for the first time high quality X-ray spectra will be obtained for all classes of X-ray sources, over a wide range of luminosity and distance.
- Con-X will address many fundamental astrophysics areas. These are described in “Science with Constellation-X”, which is available at <http://constellation.gsfc.nasa.gov/science>. The key science objectives include:
 - Black Holes
 - Observe matter spiraling into black holes and test the predictions of General Relativity
 - Study distant/faint sources to trace the evolution of black holes with cosmic time
 - Dark Energy and Dark Matter
 - Use clusters of galaxies to trace dark matter and as probes for the amount and evolution of dark energy
 - Cycles of Matter and Energy
 - Investigate the influence of black holes on galaxy formation
 - Search for the hot missing matter in the Cosmic Web
 - Study behavior of matter at extreme densities & magnetic fields using neutron stars
 - Measure heavy elements in Supernovae

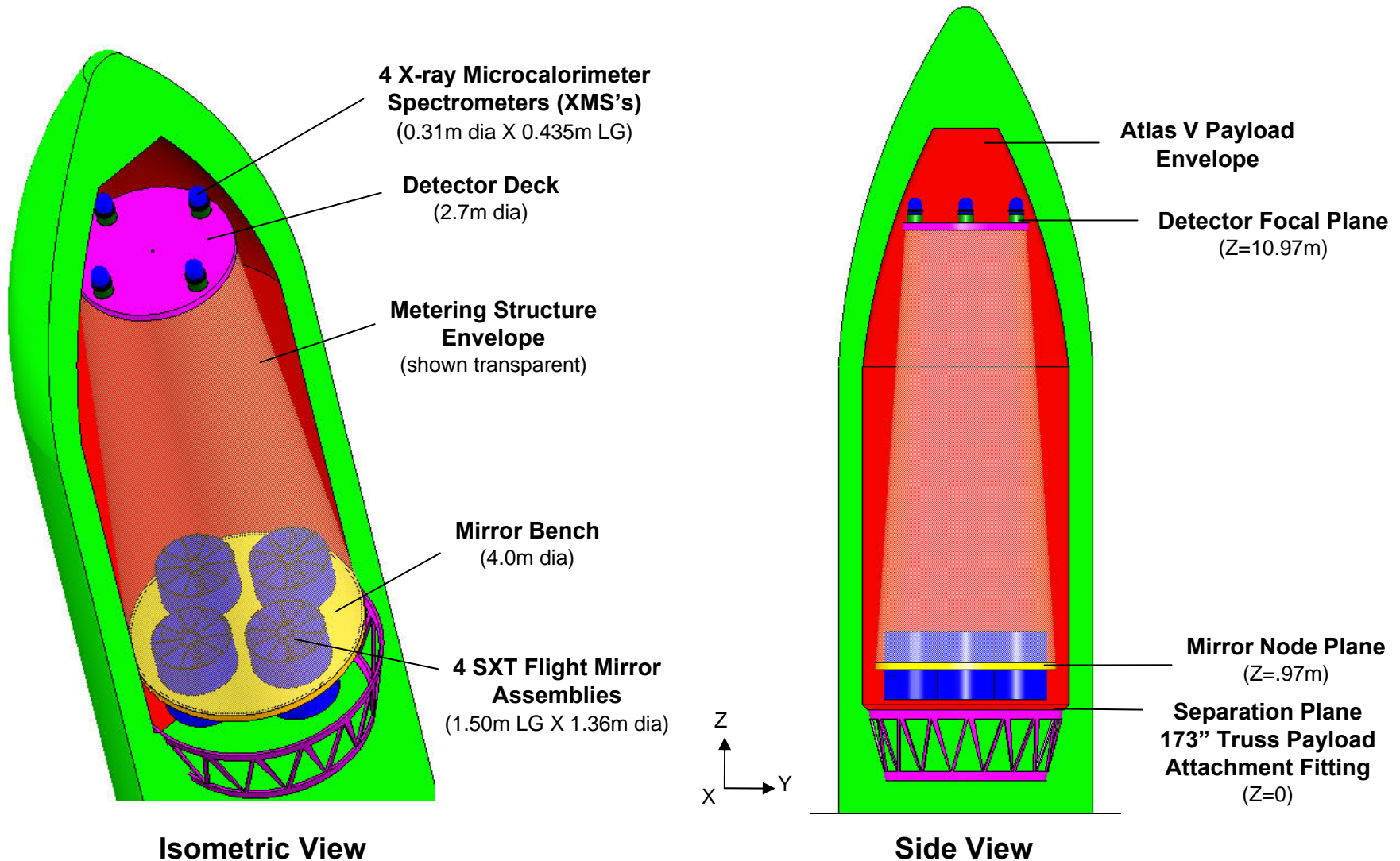
Con-X Atlas V Configuration

- To significantly decrease the cost of the mission while maintaining the science capabilities, the Con-X project is studying a streamlined mission approach:
 - Launch on a single Atlas V 551
 - Mass and volume meet launch vehicle constraints to L2
 - Basic Payload includes 4 Spectroscopy X-ray Telescope (SXT) mirror assemblies each with a corresponding X-ray Microcalorimeter Spectrometer (XMS)
 - Science Enhancement Package (SEP) to augment the performance capabilities of the basic payload
 - Simpler system for lower overall program risk

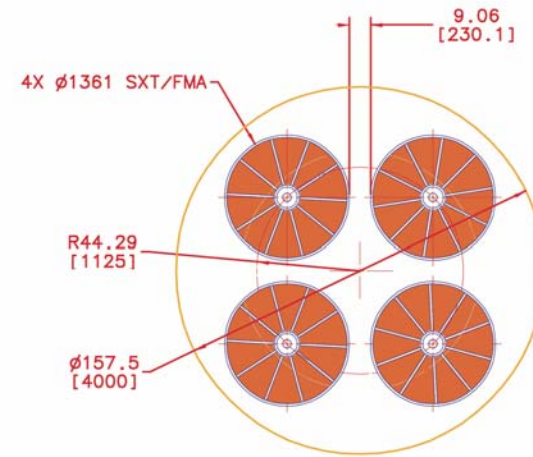
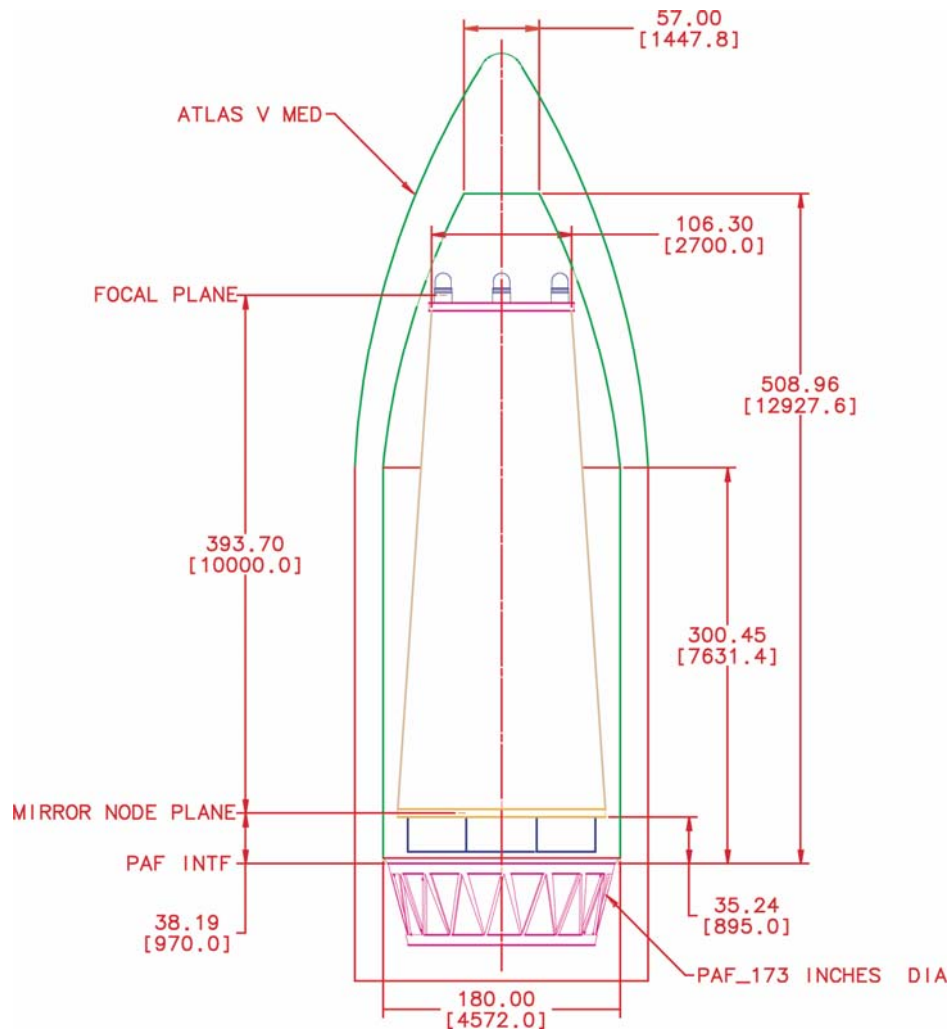


ATLAS V 551

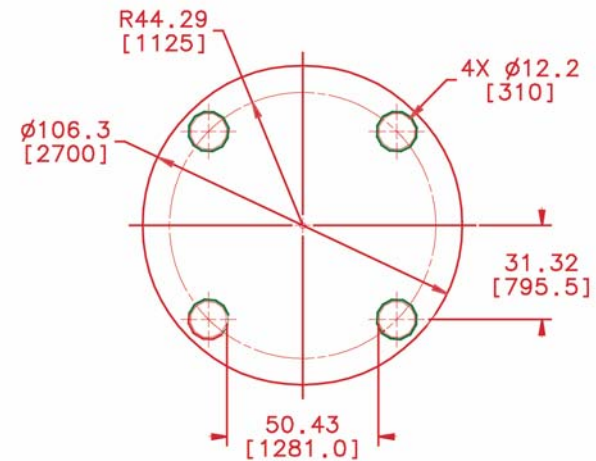
Con-X Atlas V Single Launch Mission Payload Layout



Dimensional Views of Atlas V Con-X Layout



Mirror Bench



Detector Deck

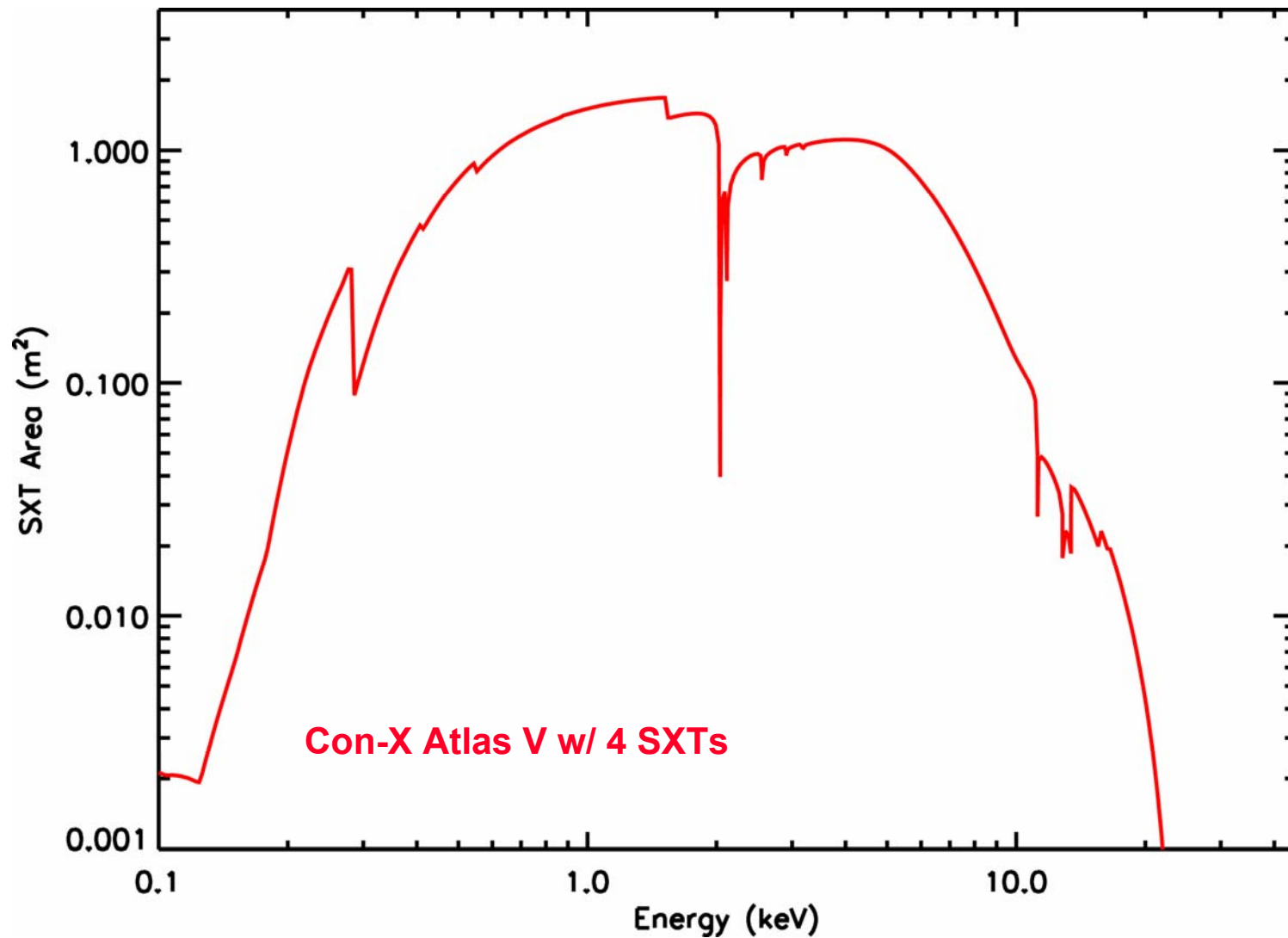
Con-X Performance Requirements

The performance capabilities of the basic payload will be augmented by the SEP

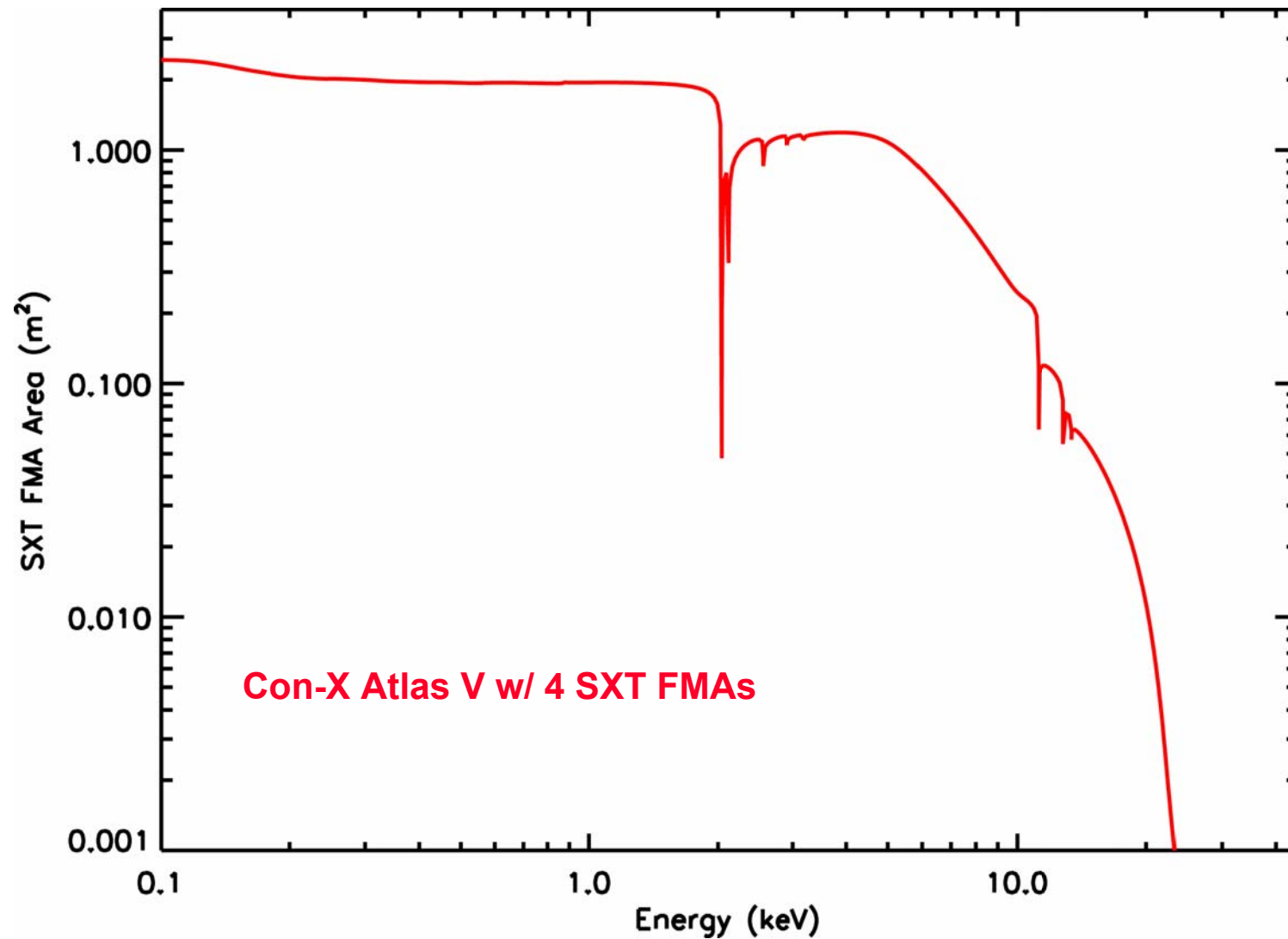
Parameter	Con-X Mission Reference Requirements	Con-X Atlas V Projected Basic Payload Capability
Effective Area: 0.25-10.0 keV 1.25 keV 6.0 keV 10.0 - 40.0 keV	1,000 cm ² 15,000 cm ² 6,000 cm ² 1,500 cm ²	≥ 1,000 cm ² 15,000 cm ² 6,000 cm ² 1,000 to 0 cm ²
Resolving Power E/ΔE (FWHM): 0.25-0.6 keV 0.6 - 6.0 keV 6.0 - 10.0 keV 10.0 – 40.0 keV	300 300 1500 10	125 to 300 300 to 1500 1500 to 2500 ~ 1000*
Angular Resolution (HPD): 0.25 - 10.0 keV 10.0 - 40.0 keV	15.0 arcsec 60.0 arcsec	15.0 arcsec ~15.0 arcsec*
Field of View: 0.25 - 10.0 keV 10.0 - 40.0 keV	2.5 arcmin 8 arcmin	2.5 arcmin ~2.5 arcmin*

* Valid for energies at which there is sufficient throughput. Effective area plots can be found on the following pages.

Con-X Atlas V: Projected Effective Area of Basic Payload



Con-X Atlas V: Projected SXT Flight Mirror Assembly Area



Science Enhancement Package

- SEP is intended to augment the basic payload capability in order to achieve the Con-X mission science objectives. Key science areas to be addressed by the SEP include:
 - Black Hole and General Relativity:
 - Utilize sensitivity at $E > 10$ keV to constrain the continuum and Compton reflection bump
 - Warm Hot Intergalactic Medium (WHIM) and AGN outflow studies:
 - Utilize resolving powers of $R > 300$ for $E < 0.6$ keV to access spectral diagnostics in abundant O VII lines
- SEP should provide some or all of the following performance enhancements:
 - Increased spectral resolution at low energies (< 0.6 keV)
 - Increased throughput at high energies (> 10 keV)
- SEP concepts that enable the science objectives may not provide precisely the same performance as the reference mission requirements.
 - SEP concepts need not provide simultaneous performance capabilities

SEP Concept Options

SEP may consist of one or more additions, augmentation, or changes to the basic payload within mass and cost constraints. SEP concepts may include, but are not limited to the following:

- **Extend High Energy Capabilities (>10 keV):**
 - Multi-layer SXT mirror shells
 - Add HXT modules
 - Alter the XMS to achieve higher energy response
- **Extend Low Energy/High Resolution Capabilities (<0.6 keV):**
 - Alter XMS to achieve higher resolution at low energies
 - Implement multiple detectors in SXT focal plane
 - Include a simplified grating/detector system

Summary

- The Con-X project is studying a streamlined mission configuration that can be launched on a single Atlas V vehicle. The payload consists of the basic SXT telescope/microcalorimeters systems and a Science Enhancement Package (SEP)
- The SEP is intended to extend the high energy capabilities (>10 keV) and/or provide high spectral resolution at low energies (<0.6 keV) to achieve the Con-X science objectives.

Appendix A

Con-X Reference Mission Configuration and Performance Information

Con-X Reference Configuration

Mission Approach:

- Single satellite with multiple identical telescopes
 - Each telescope provides a portion of the total effective area
- Delta IV launch
- Deep space (L2) orbit allows:
 - High observing efficiency
 - Stable thermal environment



Delta IV H

Optics Module

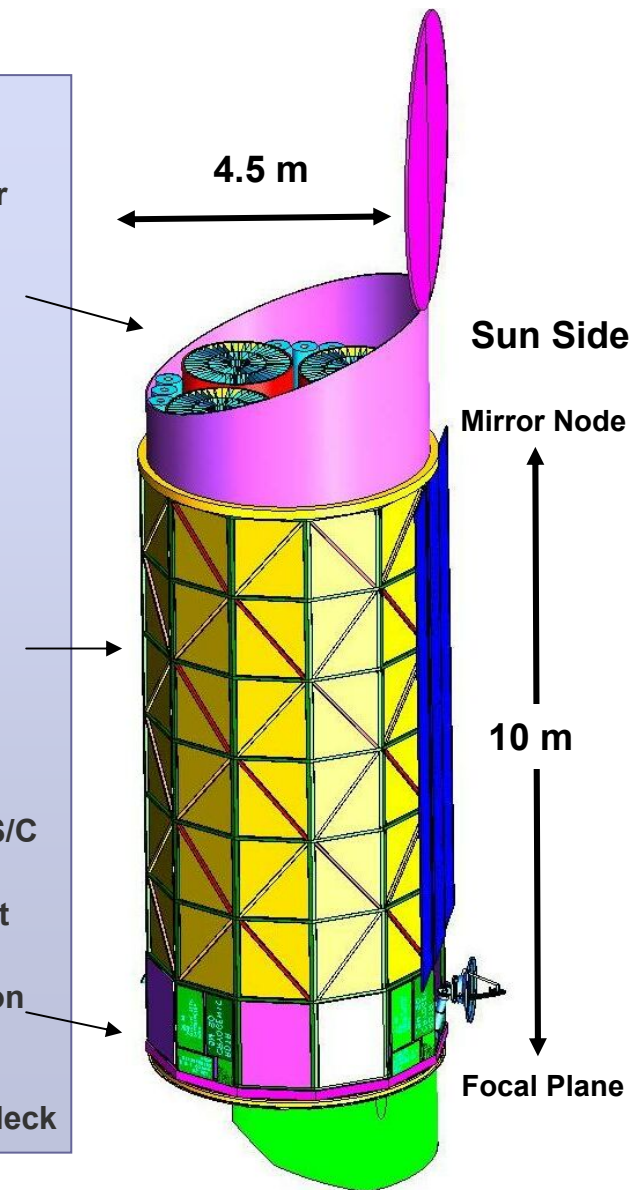
- 4 Spectroscopy X-ray Telescope (SXT) Flight Mirror Assemblies
- 12 Hard X-ray Telescope (HXT) mirrors
- Door/sunshade and internal cover/door
- Star Tracker

Metering Structure Module

- Fixed metering structure
- Light and Micrometeoroid shield
- Internal Baffles
- Solar Arrays

Focal Plane Module (FPM) and S/C Bus

- Detector systems on aft-most deck
- Electronics for instruments on panels and Benches
- Spacecraft bus subsystem components on panels and deck

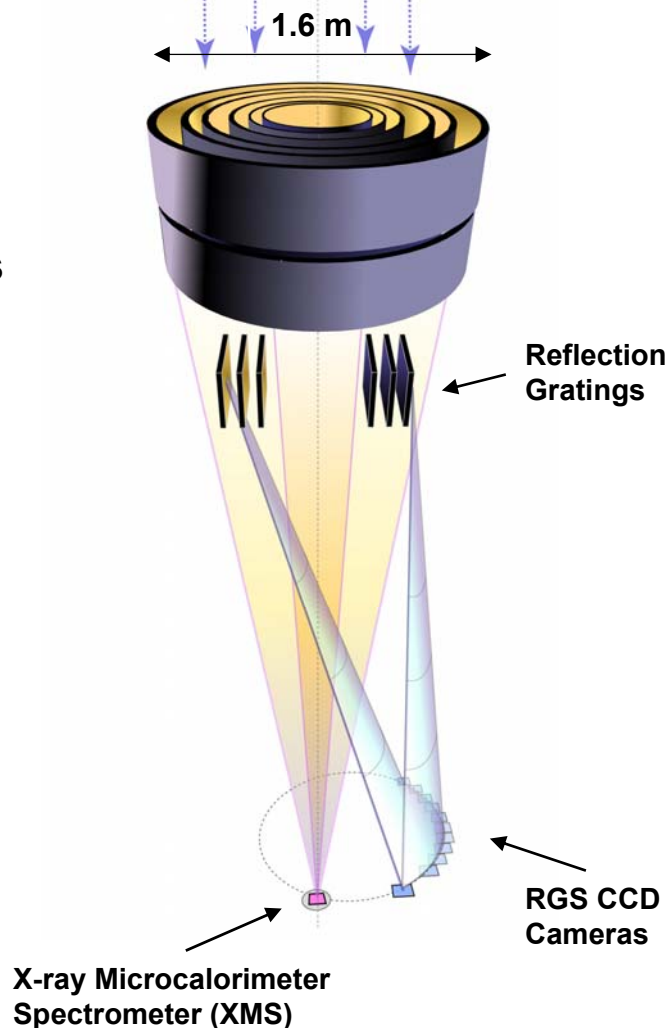


Con-X Reference Mission Payload

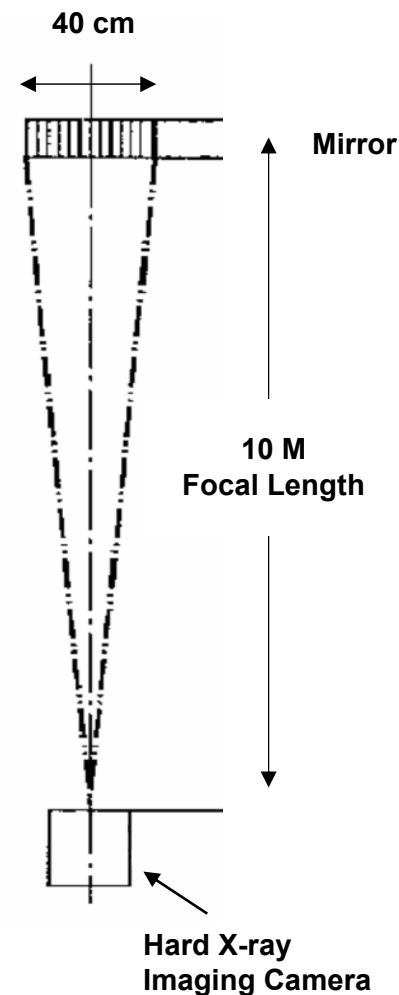
- 4 Spectroscopy X-ray Telescopes (SXT)
- 12 Hard X-ray Telescopes (HXT)
- All instruments operate simultaneously

(Geometry is highly exaggerated)

4 Spectroscopy X-ray Telescopes

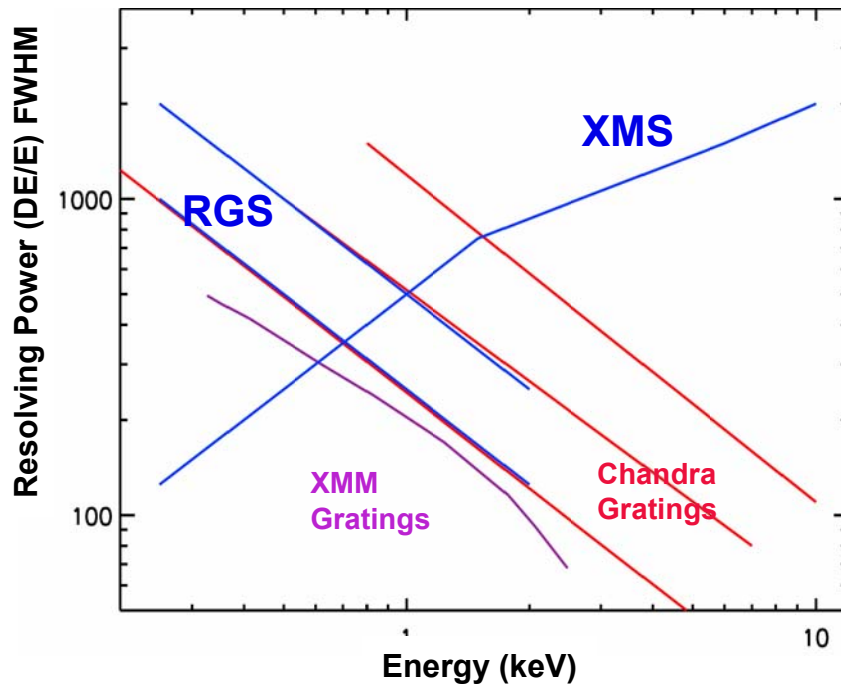


12 Hard X-ray Telescopes

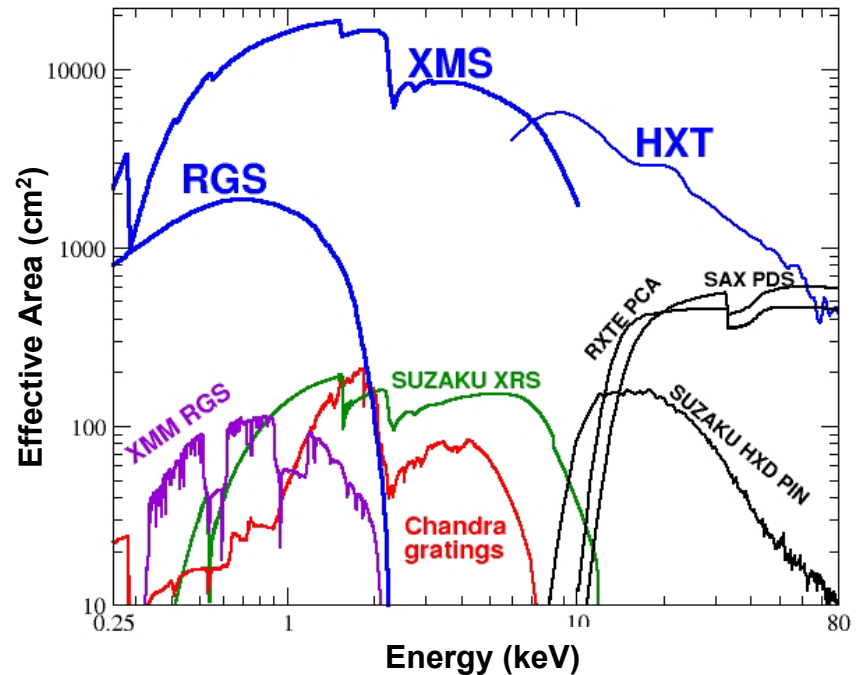


Con-X Reference Mission Capabilities

Comparison of X-ray Mission Resolving Power
(Constellation-X instruments in blue)



Comparison of X-ray Mission Collecting Area
(Constellation-X instruments in blue)



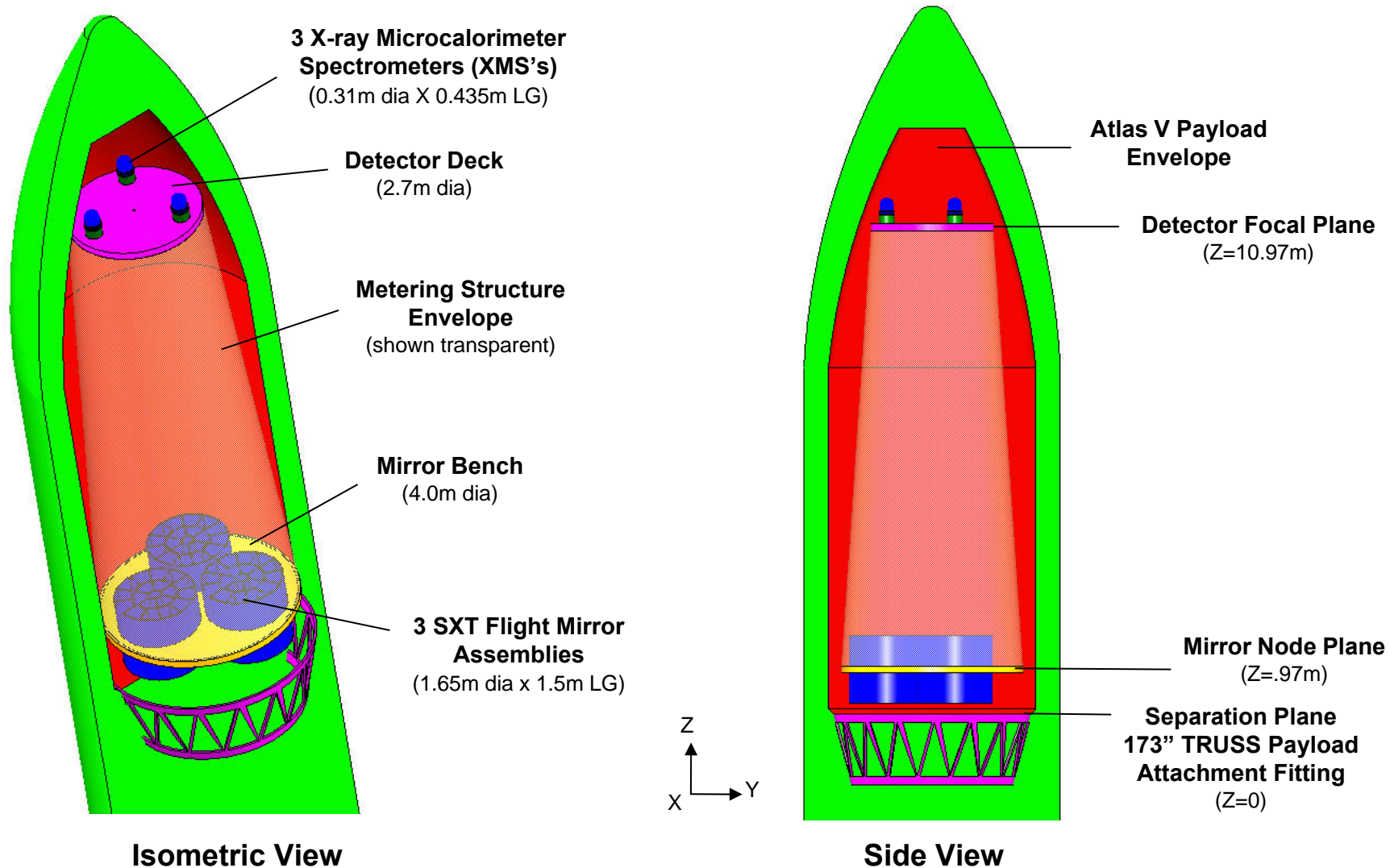
Constellation-X brings a factor of 25-100 increase in capability over current missions and will open the window of X-ray spectroscopy

Constellation-X will turn X-ray Astronomy into X-ray Astrophysics!

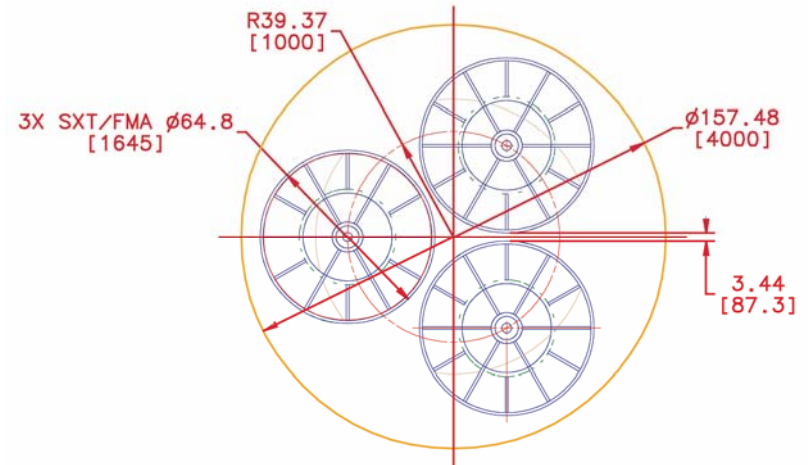
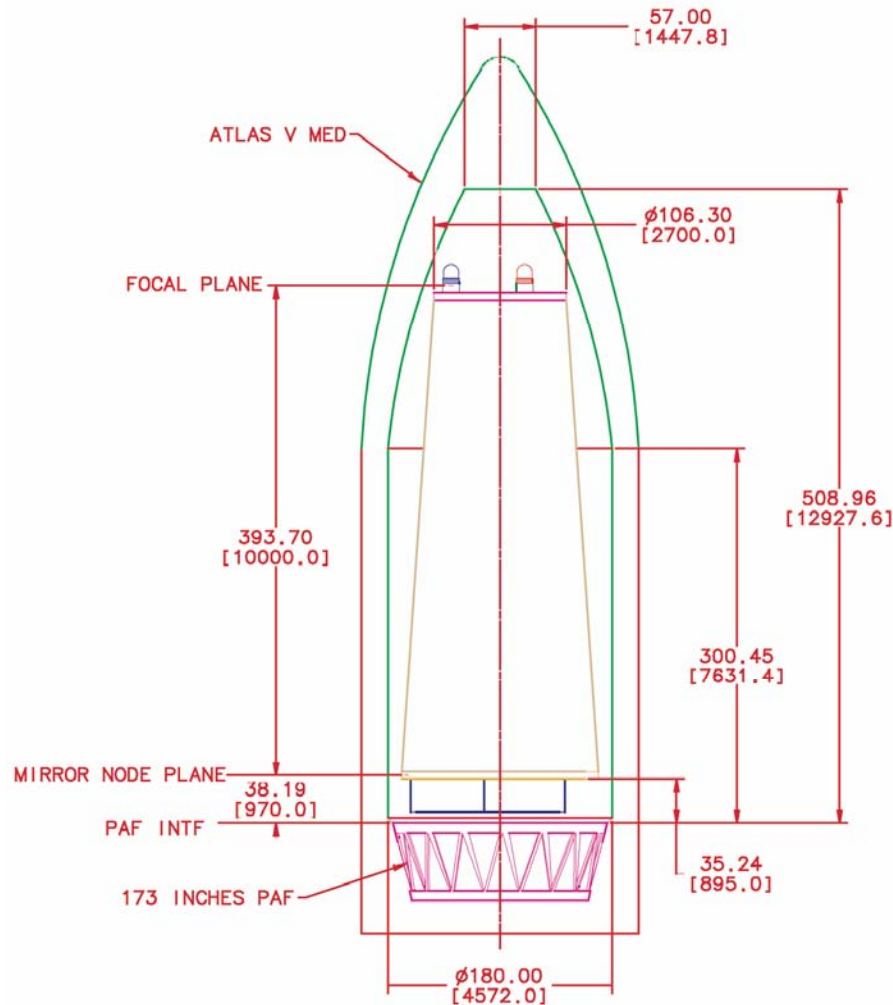
Appendix B

3 SXT Alternative Mission Configuration and Performance Information

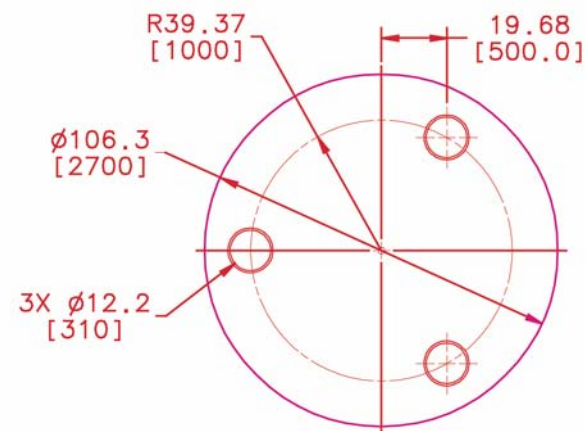
Con-X Atlas V Mission Payload Layout: 3 SXT Alternative



Dimensional Views of Atlas V Con-X Layout: 3 SXT Alternative

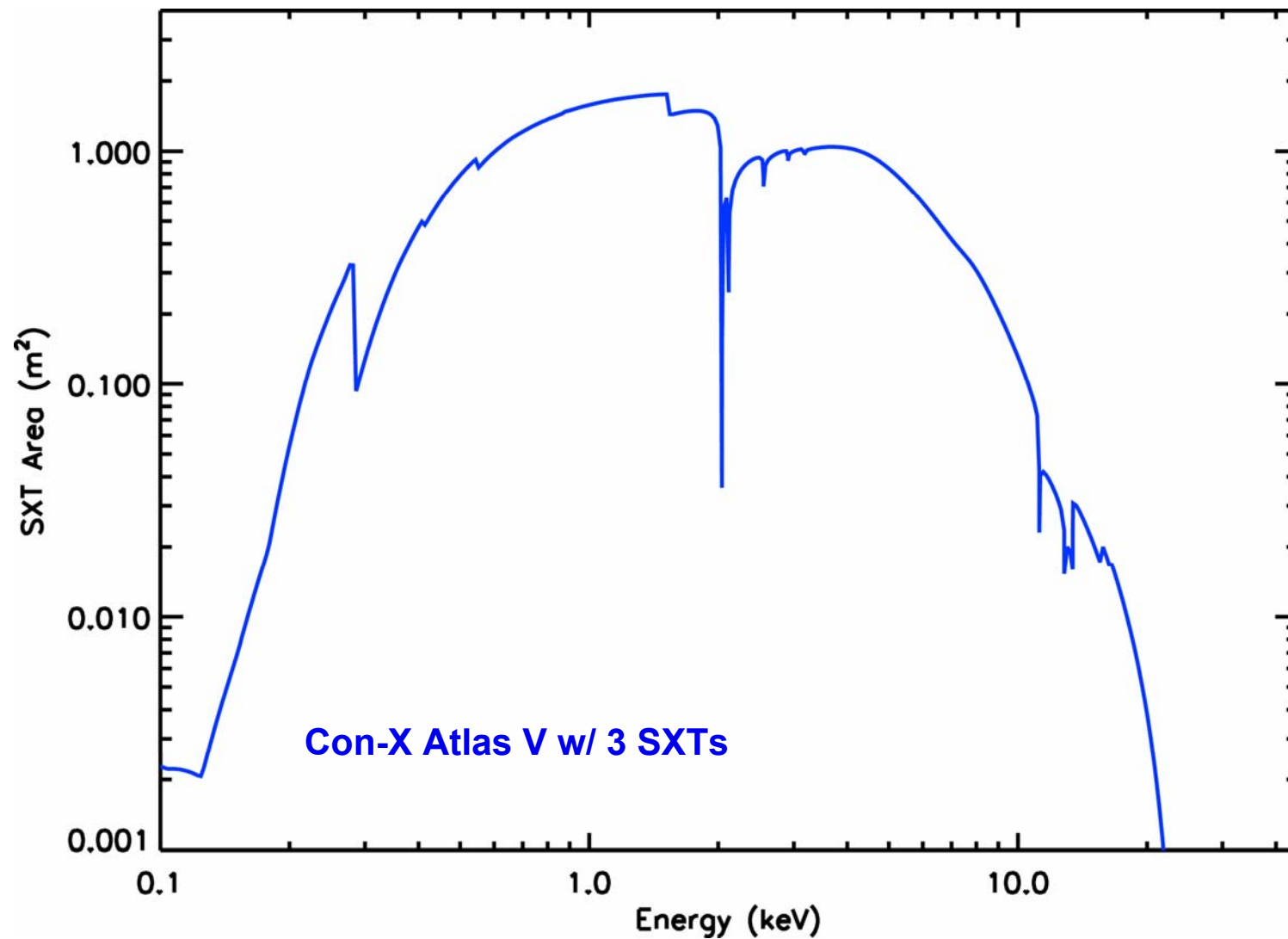


Mirror Bench

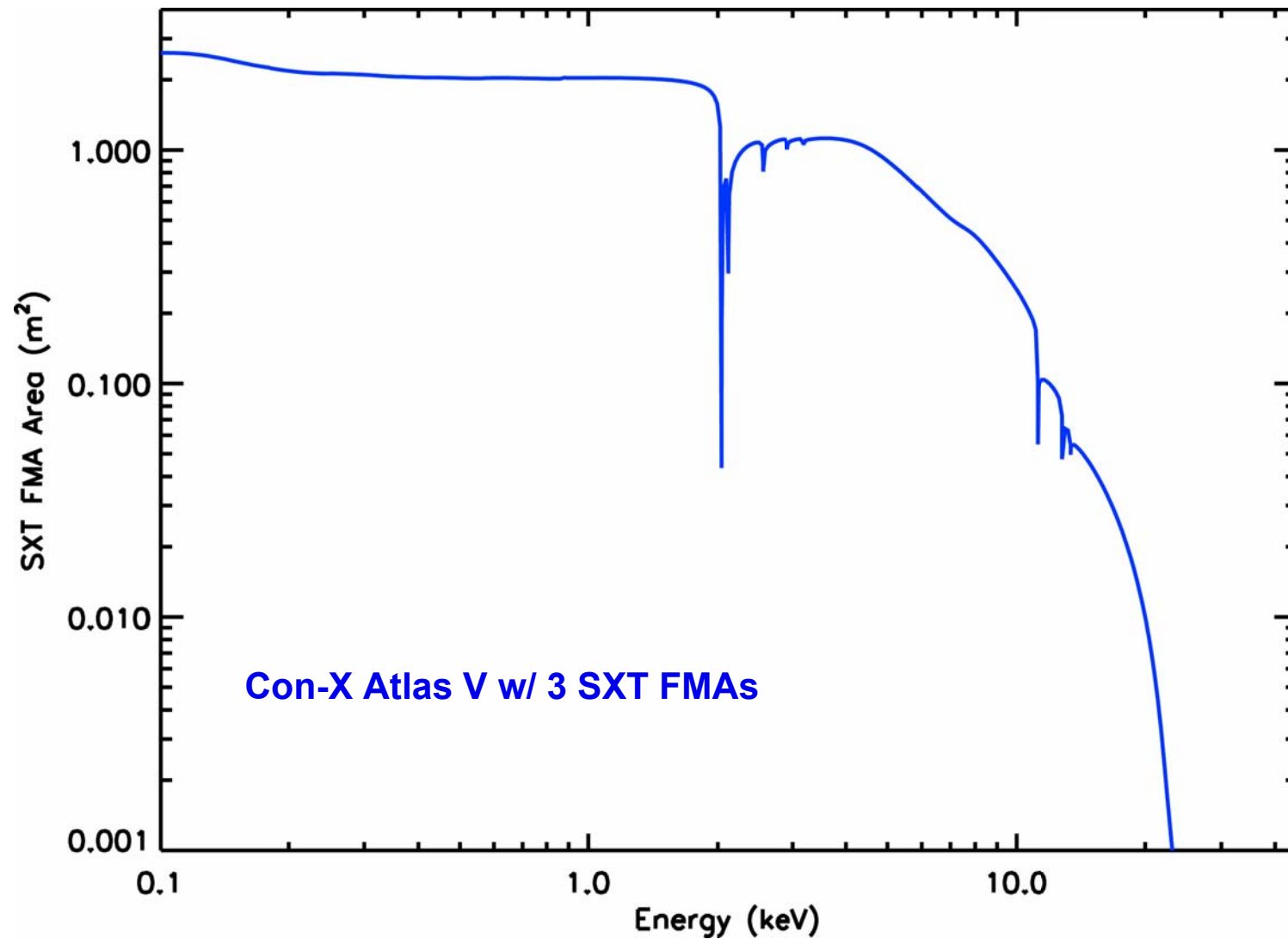


Detector Deck

Projected Effective Area of Basic Payload: 3 SXT Alternative



Projected SXT Flight Mirror Assembly Area: 3 SXT Alternative



Acronym List

AGN	Active Galactic Nuclei
Con-X	Constellation-X
FMA	Flight Mirror Assembly
FPM	Focal Plane Module
HPD	Half-Power Diameter
HXT	Hard X-ray Telescope(s)
RGS	Reflection Grating Spectrometer(s)
S/C	Spacecraft
SEP	Science Enhancement Package
SXT	Spectroscopy X-ray Telescope(s)
WHIM	Warm-Hot Intergalactic Medium
XMS	X-ray Microcalorimeter Spectrometer(s)